Benthic Fauna Assemblages in Batchawana Bay, Lake Superior

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by

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ABSTRACT

Dermott, R. M. 1984. Benthic fauna assemblages in Batchawana Bay, Lake Superior. Can. Tech. Rep. Fish. Aquat. Sci. 1265: iii + 17 p.

The benthic fauna of oligotrophic Batchawana Bay consists of three assemblages dependent on depth and sediment composition. The deep-water fauna is more similar to that of Georgian Bay than that in Lake Superior. As a result of the enclosed nature of the bay, the warm shallows support a fauna more typical of the historical fauna in the now eutrophic embayments of the lower Great Lakes.

Key words: macroinvertebrates, community, profundal, sandy shallows, Pontoporeia, Hexagenia, Sphaerium, gastropods, oligotrophic.

RÉSUMÉ

Dermott, R. M. 1984. Benthic fauna assemblages in Batchawana Bay, Lake Superior. Can. Tech. Rep. Fish. Aquat. Sci. 1265: iii + 17 p.

La faune benthique de la Baie Batchaouna, qui est oligotrophe, est constituée de trois assemblages selon la profondeur et la composition des sédiments. La faune d'eau profonde ressemble beaucoup plus à celle de la Baie Georgienne qu'à celle du Lac Supérieur. A cause de la nature fermée de la baie, les hauts-fonds chauds hébergent une faune plus caractéristique de la faune historique dans les baies maintenant eutrophes des Grands Lacs d'aval.

Mots clefs: macro-invertébrés, communauté, profonde, hauts-fonds sablonneux, Pontoporeia, Hexagenia, Sphaerium, gastropodes, oligotrophe.

Introduction

The macrobenthic communities of inshore areas and embayments of the Great Lakes have frequently been investigated in relation to cultural enrichment. Changes in species composition due to reduced water quality have been observed in all the lakes with major changes occurring in Saginaw Bay (Schneider et al., 1969), Western Lake Erie (Carr and Hiltunen, 1965) and Toronto Harbour (Brinkhurst, 1970). Less common are studies of the benthic fauna in undisturbed nearshore areas (Hiltunen, 1969; Mozley and Winnell, 1975; and Hare and Carter, 1977).

The present study investigated the fauna of relatively shallow Batchawana Bay, eastern Lake Superior. The study was part of the assessment of contaminant dynamics in the partially enclosed bay. Thomas (1966) undertook a larval lamprey survey of the bay, collecting qualitative samples of the benthic invertebrates and fish species present. As he did not identify the Diptera or Oligochaeta, or estimate the relative abundance of the macroinvertebrates, particular attention was given to these parameters.

Area Description

The bay is 40 km north of Sault Ste. Marie and is surrounded by heavily forested hills (300 m vertical), composed of Precambrian granitic rocks. The study area has limited human influence. Less than 10 percent of the shore line has cottage development, primarily along the southeast shore. The majority of the total contaminants in the bay enters via long-range atmospheric input.

Maximum depth in the enclosed section of the bay is 46 m, occurring to the east of Batchawana Island. Much of the bay is less than 6 m deep with extensive sand shoals (Fig. 1). As a result, warm surface water accumulates during the summer reaching 17 to 22°C (J. Kelso, unpublished). Maximum algal biomass was 600 mg m^3 (R. Love, unpublished), which classifies the bay as oligotrophic according to Vollenweider (1968).

Methods

Duplicate Ponar samples (0.05 m^{-1}) were collected at 27 sites during May and September 1977 (Fig. 1). Twenty-three of these sites followed a universal transverse mercator grid used during a sediment survey of the bay in 1976 (R. Thomas, unpublished). In addition, two transect lines on the sandy shoals were sampled at 3, 5, and 10 m depths, at sites ES north of Batchawana Island (grid J7) and DS south of the island (grid E6). Percent sand and silt, mean particle size, and organic content of the sediments were analysed following the methods in Thomas et al. (1972).

The sediments were washed through a sieve of 0.18 mm mesh. The retained organisms were preserved in ten percent formalin, while the molluscs were preserved in 70 percent alcohol. The organisms were identified, enumerated, and the wet weights of each taxonomic group tallied. Dry weight was calculated from the percent dry weight estimated for each taxon. The Oligochaeta and Chironomidae were mounted in balsam for identification. The nomenclature of these taxa follows Brinkhurst and Jamieson (1971), and Oliver et al. (1978). Nomenclature of the Mollusca follows Clark (1973), while that of the remaining taxa follows Holsinger (1972), and Pennak (1978).

Hierarchial clustering was undertaken on the May samples, using the percentage similarity of community (PSc) to obtain a numeric measure of similarity between the 27 sites examined. This was calculated as:

$$PSc = 100 - 0.5 \sum |a - b|$$

where a and b are, for each species, the percentages of the total animals from the sites A and B. Diversities of the communities were calculated using the Shannon index of diversity:

$$H = - \sum (Ni/N) \ln (Ni/N)$$

where Ni is the abundance of each taxon, N is the total abundance and ln is the natural log.

RESULTS

Table 1 lists the physical data of depth, percent sand, and organic content of the sediment at the sample sites. The average total dry weight of the macroinvertebrates at the sample sites during 1977 is displayed in Figure 2. The greatest biomass (standing stocks) occurred at a depth of less than 3 m, along the shoreline and on the sandy shoals south of Batchawana Island. The lowest occurred in deeper water near the northern inlet to the bay, and along the steep, rocky eastern shoreline.

The benthic fauna was readily divided into three major communities dependent on sample depth and substrate. These being: the profundal species inhabiting fine sediments at depths greater than 20 m,

those at intermediate depths (5 to 20 m) on fine sediments with particle size less than 180 microns; and those species inhabiting sandy sediments at a depth less than 5 m. The average total abundance and biomass from the sites of these three communities are listed in Table 2 for both May and September. Average percent composition of the fauna at these three depth zones in Batchawana Bay are also listed in Table 2.

There were few differences in abundance between spring and fall. However, mean biomass in the shallow zone was reduced ($p<0.1$) during September, due to a reduction in mean weight of the Sphaeriidae and Gastropoda. The seasonal difference in the biomass in the intermediate depth zone was insignificant ($p<0.2$). This difference was due to a reduction in mean weight of the mayflies and chironomids, both of which reproduce in early summer. There was no seasonal difference in the abundance or biomass of the profundal community.

Hierarchial clustering by Ward's minimum variance (Figure 3), separated the sites into three major groups, confirming the separation based on depth. However, clustering subdivided the sites of intermediate depth on the basis of the sediment percent sand composition. This was greater than ten percent in the grouping of sites A10 to M6 and greater than 80 percent in the group DS-10 to 14.

The Profundal Zone

Diversity in the deep water was low, with the Shannon index of numeric diversity (H) ranging between 1.5 and 2.2. From 1976 to 1978 the profundal zone supported a near consistant abundance of Chironomus salinarius grp., with cyclic fluctuations in the abundance of Pontoporeia (Figure 3). As in all the Great Lakes except Lake Erie, this zone was dominated by Pontoporeia. Tubifex kessleri and Limnodrilus profundicola were the prevalent oligochaetes (Table 3). The deepwater chironomids in the bay were Chironomus salinarius grp. and Micropsectra sp. with Heterotrissocladius oliveri predominant during early autumn (Table 4). As M. Thomas (1966) published extensive lists of the taxa collected in Batchawana Bay, only lists of the Chironomidae and Oligochaeta are presented in the present study (Tables 3 and 4).

Intermediate Depth

The silt-inhabiting community at intermediate depths was much more diverse than the deepwater association, with H values ranging from 1.9 to 3.0. On a weight basis, the major species in this zone was the burrowing mayfly Hexagenia limbata. During May, this species comprised 35 percent of the biomass although it accounted for less than 2 percent of the mean abundance. The two year life cycle of Hexagenia resulted in limited seasonal variation of biomass.

The Chironomidae averaged 22 percent of the dry weight (Table 2), with a wide array of species present (Table 4). Heterotrissocladius changi, Tanytarsus spp. and Dicrotendipes spp. dominated the chironomids inhabiting this depth zone. The predominant oligochaetes were Peloscolex multisetosus multisetosus and Aulodrilus americanus. Sparganophilus was restricted to fine sediments at less than 10 m, while all the Lumbriculidae were collected only from sandier sediments at depths less than 20 m (Table 3).

Over the depth range of 3 to 15 m, the firmer sediments (containing up to 80 percent fine sand) sustained large numbers of Unionidae, dominated by Lampsilus radiata and Eliptio complanata. These widespread but contagiously distributed clams averaged 1.44 per m^{-2} (SE = 0.57, df = 62) representing a dry shell-free biomass of 1.86 g m^{-2} (SE = 1.34).

Sandy Shoals

The predominant sediment on the shallow shoal areas of Batchawana Bay (<3 m depth) was medium sand with a mean particle size greater than 250 microns. At depths between 3 and 5 m, the sediment was composed of finer grades of sand. Molluscs dominated the community on these shoals, with the gastropods composing up to 47 percent of the shell-free biomass. Sphaerium nitidum, S.striatinum, Goniobasis livescens, Campeloma decisum and the smaller species, Amnicola spp. and Cincinnatia cincinnatiensis were predominant. This community was diverse, with H values ranging from 2.3 to 3.1.

The extensive sandy shoal area to the south of Batchawana Island, supported the largest biomass (10 g m^{-2}) collected in the bay. The average population was 2190 m^{-2} at transect site DS-5. The chironomids Cladotanytarsus spp. and Stictochironomus dominated this site, but the majority of the shell-free weight was due to S.nitidum and C.decisum. The dominant chironomids elsewhere on these sandy shoals were Polypedilum spp. and Cladotanytarsus spp., while Nilothauma

sp., Paralaterborniella nigrohalterale and the Tipulidae, Limnophyta sp. were restricted to this habitat. Dominant oligochaetes on these shoals were Stylodrilus heringianus, Peloscolex multisetosus and Aulodrilus americanus, with P.superiorensis and Uncinais uncinata restricted to this zone.

Likewise, the Sphaerium species, Ephemera simulans, the caddisflies, Molonna sp. and Oecetis sp., as well as the dragonflies, Macromia sp. and Gomphus sp. were restricted to the shallows on sandy sediment. Quantatative collections made by divers indicated that the crayfish Orconectes propinquus was abundant among the rocky outcrops and cobbles in shallow water, together with the normally riparian insects Acroneuria lycorias, Heptagenia pulla and, less common, the beetle, Psephenus sp.

Discussion

The deepwater community of Batchawana Bay was similar to that found in Georgian Bay (Loveridge and Cook, 1976) or the Apostle Islands region of Lake Superior (Hiltunen, 1969). The regular presence of the chironomid Protanypus in Batchawana Bay was indicative of the oligotrophic nature of the bay. In the Great Lakes, this species is restricted to the Upper Lakes. The oligochaetes Peloscolex variegatus and Mesenchytraeus were absent in Batchawana Bay, although common in Lake Superior (Cook, 1975). Likewise, no specimens of Phallodrilus hallae were collected from Batchawana Bay, in spite of its abundance in Lake Superior (Cook, 1975). Its absence in the bay and neighbouring Whitefish Bay may be due to insufficient depth or the presence of competing tubificids, particularly Rhyacodrilus (Dermott, 1978).

Benthic abundance in adjacent Whitefish Bay (3000 m^{-1}, Cook, 1975) was considerably greater than in Batchawana Bay. However, the total biomass was of a similar magnitude. Other than Pontoporeia, the prominant organisms of Whitefish Bay, Paracladopelma, Dicrotendipes, and Stylodrilus, were restricted to the firmer sediments of Batchawana Bay at depths less than 20 m. Sediment sizes in Whitefish Bay averaged 0.18 mm (Cook, 1975) matching that in the shallower areas of Batchawana Bay.

Stylodrilus is the dominant oligochaete in the deeper regions of Lake Superior (Cook, 1975), Lake Michigan (Howmiller, 1974), and Lake Ontario (Nalepa and Thomas, 1976). However, in Batchawana Bay all the Lumbriculidae present were restricted to shallower areas with firmer sediments, while absent from the deeper sites. Hare and Carter (1977) reported a similar distribution of Stylodrilus in Parry Sound, Georgian Bay. The data of Brinkhurst and Jamieson (1971) and Howmiller (1974) indicated a preference by Stylodrilus for sandy sediments or compact glaciolacustrine clay rather than the fine muds of the depositional zones.

M. Thomas (1966) collected several species of odonates, caddisflies and gastropods that were not found in the present study. The leeches Erpobdella punctata and Nephelopsis obscura present in Thomas' samples (1966) were not collected in this study, nor were the crustacea Gammarus pseudolimnaeus and the clam Pisidium dubium. Mayflies collected in this survey but not reported in Thomas' (1966) extensive list were the common Caenis sp., Siphlonurus sp. and the rarer Tricorythodes sp, Brachycercus lacustris and Heptegenia pulla grp. The corixid Sigara sp. was common in the shallows during 1977. The minor differences in species lists were due to sampling methods and a greater number of inshore samples collected by Thomas, rather than any changes in environmental conditions over the decade between the two surveys.

Ostracods and nematodes were rare in Batchawana Bay; the size of the screen used (0.18 mm) was not large enough to account for their absence in the samples. Candona sp. and Cytherissa sp. were the only ostracods collected. The majority of the nematodes collected were Mermithoidea, which are parasitic on the chironomids. Cook (1975) and Loveridge and Cook (1976) found nematodes numerous in Lake Superior and Georgian Bay.

The benthic community of the intermediate depth of Batchawana Bay appears to parallel the pre-eutrophic populations in several of the shallow regions and embayments of the Great Lakes, particularly Green Bay (Howmiller and Beeton, 1971), and Western Lake Erie (Carr and Hiltunen, 1966). Following a reduction of the Hexagenia population, the 1952 population in Green Bay averaged 48 percent chironomids, 23 percent oligochaetes, while the Sphaeriidae formed 16 percent of the organisms (Howmiller and Beeton, 1971). A similar proportion of chironomids was present in Batchawana Bay. However, the gastropods and mayflies were more important components of the fauna. As a result of cultural eutrophication, the historical populations of Hexagenia in Saginaw Bay, Lake Michigan, had been

reduced from approximately 60 to 9 m^{-2} (Schneider et al., 1969). The original population were similar to the average abundance (67 m^{-2} SE=19) at a similar depth in Batchawana Bay. Carr and Hiltunen (1966) found an immense increase in the tubificid populations of western Lake Erie between 1930 and 1961, while the mayfly population had declined from 140 to less than 1 m^{-2}.

The sandy central ridge of Saginaw Bay (Schneider et al., 1969) maintained large populations of Cryptochironomus, Pseudochironomus and Ephemera, which were also prominent on the sandy shoals of Batchawana Bay. Shelford and Boesel (1942) reported that the sandy shoals at the mouth of the Detroit River supported a benthic community dominated by the molluscs, Sphaerium, Goniobasis and Amnicola, which composed most of the biomass on the shallow shoals of Batchawana Bay. Freitag et al., (1976) found the gastropods, caddisflies, and in particular Hexagenia, common in Nipigon Bay, northern Lake Superior. As in Batchawana Bay, the surface water of enclosed Nipigon Bay warms to above 19°C, supporting a benthic community untypical of Lake Superior.

The shallow, warm-water conditions in Batchawana Bay, supports a benthic community formally charcteristic of the shallow, now eutrophic areas of the lower Great Lakes. The deep-water fauna of the bay is similar to that of Nipigon Bay, Lake Michigan, and Georgian Bay and not characteristic of ultra-oligotrophic Lake Superior. This is due to differences in the trophic status and relative depths of the two regions of Lake Superior.

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List of Tables

Table 1. Depth and sediment characteristics at the sample sites in Batchawana Bay.

Table 2. Mean number, dry weight and percent composition of the taxa present in the three depth zones of Batchawana Bay.

Table 3. Average abundance of the Oligochaeta collected from Batchawana Bay.

Table 4. Average abundance of the Chironomidae collected in Batchawana Bay.

Table 1. Depth and sediment characteristics at the sample sites in Batchawana Bay.

Site	Depth m	% sand	% organics loss 500 C	mean particle size µm
A-10	15	8.1	5.3	180
C-8	9	0.9	6.1	4
D-10	38	1.4	6.8	4
D-12	18	77.1	5.6	76
DS-3	3	94.5	1.2	650
DS-5	5	89.0	0.7	250
DS-10	10	87	4.7	116
E- 7	10	85.6	5.1	103
ES-3	3	93	0.5	250
ES-5	5	89	0.7	200
ES-10	10	82	0.9	112
F- 7	8	16	0.7	13
F-10	40	2.9	2.3	3
G- 8	11	69.7	1.3	58
H-11	45	7.0	2.3	4
H-13	12	92	1.2	57
I- 4	7	87	0.9	189
I- 5	1	90	0.7	203
I-10	44	3.9	3.8	3
J- 4	25	8.1	2.9	8
J-11	27	6.3	5.9	5
K- 7	21	9.8	4.9	6
L- 2	22	89	1.6	203
L-5	30	2.3	5.2	8
M- 2	15	13.7	8.5	8
M- 6	17	13.2	3.9	14
N- 4	14	3.0	5.4	5

Table 2. Mean number, dry weight m^{-2} (standard error in brackets) and average percent composition of the taxa in the three depth zones of Batchawana Bay, excluding the Unionidae.

	Inshore		Intermediate		Deep	
mean depth	3.4 m		10.8 m		35.5 m	
Total per m^2	no.	mg.	no.	mg.	no.	mg.
May	2492	4907	1658	1431	1273	348
	(410)	(2580)	(228)	(581)	(194)	(37)
Sept.	1644	566	1413	509	1281	395
	(495)	(253)	(200)	(131)	(239)	(76)
Percent composition						
Oligochaeta	7.6	0.8	12.4	2.9	17.5	14.7
Amphipoda	6.1	0.9	2.6	0.6	38.9	39.6
Sphaeriidae	2.8	24.2	5.8	15.8	19.8	6.2
Gastropoda	15.9	47.3	6.3	6.7	0	
Isopoda	0.5	0.5	0.3	0.5	0	
Ephemeroptera	0.6	1.1	4.0	28.6	0	
Trichoptera	0.3	0.2	0.1	0.1	0	
Chironomidae	48.9	1.9	56.9	22.6	20.1	35.7
Unionidae			1.4 m^{-2}	1.8 $gm \cdot m^{-2}$		
shell-free biomass						

Table 3. Average abundance of the Oligochaeta collected from Batchawana Bay during 1977. Absent = '; occurrence = +, or < 1 m^{-2}.

	5 m	5 - 20 m	25 m
Lumbriculidae			
Lumbriculus variegatus	6.6	2.3	.
Eclipidrilus lacustris	3.9	1.1	.
Stylodrilus heringianus	33.6	16.4	1.1
Enchytraeidae	13.4	1.1	.
Tubificidae			
Peloscolex multisetosus multisetosus	121.0	80.3	3.4
P. freyi	5.1	3.7	.
P. superiorensis	1.3	.	.
Rhyacodrilus coccineus	1.3	1.1	24.7
R. sodalis	.	2.8	8.1
Aulodrilus americanus	14.7	47.2	.
A. limnobius	1.3	3.9	1.1
A. pigueti	.	4.3	.
Potomothrix vejdovskyi	.	1.1	.
Tubifex tubifex	.	1.1	2.4
T. kessleri americanus	.	+	54.2
Limnodrilus hoffmeisteri	+	6.1	15.0
L. claparendeanus	2.6	.	.
L. profundicola	.	5.6	28.1

continued...

(Table 3 continued)

	5 m	5 - 20 m	25 m
Naididae			
Nais communis / variablis	.	+	.
N. pseudobtusa	.	9.4	.
Paranais frici	.	1.5	.
Pristina foreli	.	+	.
Piguetiella michiganensis	.	+	.
Stylaria lacustris	1.3	1.5	.
Uncinais uncinata	2.6	.	.
Sparganophilidae			
Sparganophilus tamesis (=eiseni)	2.6	2.3	.

Table 4. Average abundance (m^{-2}) of the Chironomidae collected in the three depth zones of Batchawana Bay during 1977. Symbols as in table 3.

	5 m	5 - 20 m	25 m
Diamesinae			
Protanypus ramosa	.	6.0	14.1
Monodiamesia bathyphila	11.9	6.4	.
Potthastia longimanus	9.4	5.1	.
Tanypodinae			
Procladius spp.	43.4	83.1	1.3
P.(Psilotanypus) bellus	2.4	6.0	.
Ablabesmyia mallochi	12.1	6.6	.
A. monilis	2.4	3.4	.
Larsia pallens	2.4	5.6	.
Thienemannimyia grp.	16.2	3.9	.
Orthocladinae			
Epoicocladius flavens	6.5	8.1	.
Nanocladius rectinervis	.	+	.
Heterotrissocladius changi	22.4	43.8	2.2
H. oliveri	.	+	43.2
Psectrocladius spp.	10.6	2.4	.
Paracladius alpicola	12.8	14.2	.
Parakiefferiella sp.	8.6	9.8	.
Eukiefferiella sp.	.	2.2	.
Crictopus spp.	1.3	1.5	.
Corynoneura sp.	2.2	+	.
Brillia sp.	1.1	.	.
Tanytarsini			
Constempellina sp.	2.4	+	.
Stempellina sp.	3.9	+	.
Stempellinella sp.	6.9	7.5	.
Rheotanytarsus sp.	+	1.5	.
Cladotanytarsus spp.	95.6	58.2	.
Tanytarsus holochlorus grp.	15.2	87.4	9.6
Micropsectra praecox grp.	.	9.4	55.2

continued...

(Table 4. continued)

	5 m	5 - 20 m	25 m
Chironomini			
Pseudochironomus fulviventris	13.0	10.2	.
Demicryptochironomus sp.	3.9	7.0	.
Cryptochironomus scimitarus	67.1	52.1	3.9
C. rolli grp.	2.6	.	.
Harnischia festigata	2.6	1.5	.
Paracladopelma winnelli	3.9	7.0	.
P. galaptera	2.6	+	.
Parachironomus sp.	+	.	.
Nilothauma sp.	13.1	.	.
Polypedilum (Tripodura) simulans	181.2	47.0	.
Endochironomus sp.	+	3.0	
Phaenopsectra (Tribelos) juncundus	31.2	12.0	.
Einfeldia cf. pagana	+	.	.
Dicrotendipes modestus	50.1	110.2	.
Chironomus salinarius grp.	.	19.4	84.2
Chironomus decorus	3.0	28.2	6.2
Stenochironomus pulchripennis	+	.	.
Paralauterborniella nigrohalterale	10.0	.	.
Stictochironomus devinctus	63.2	12.1	.
Microtendipes sp.	1.3	2.2	.

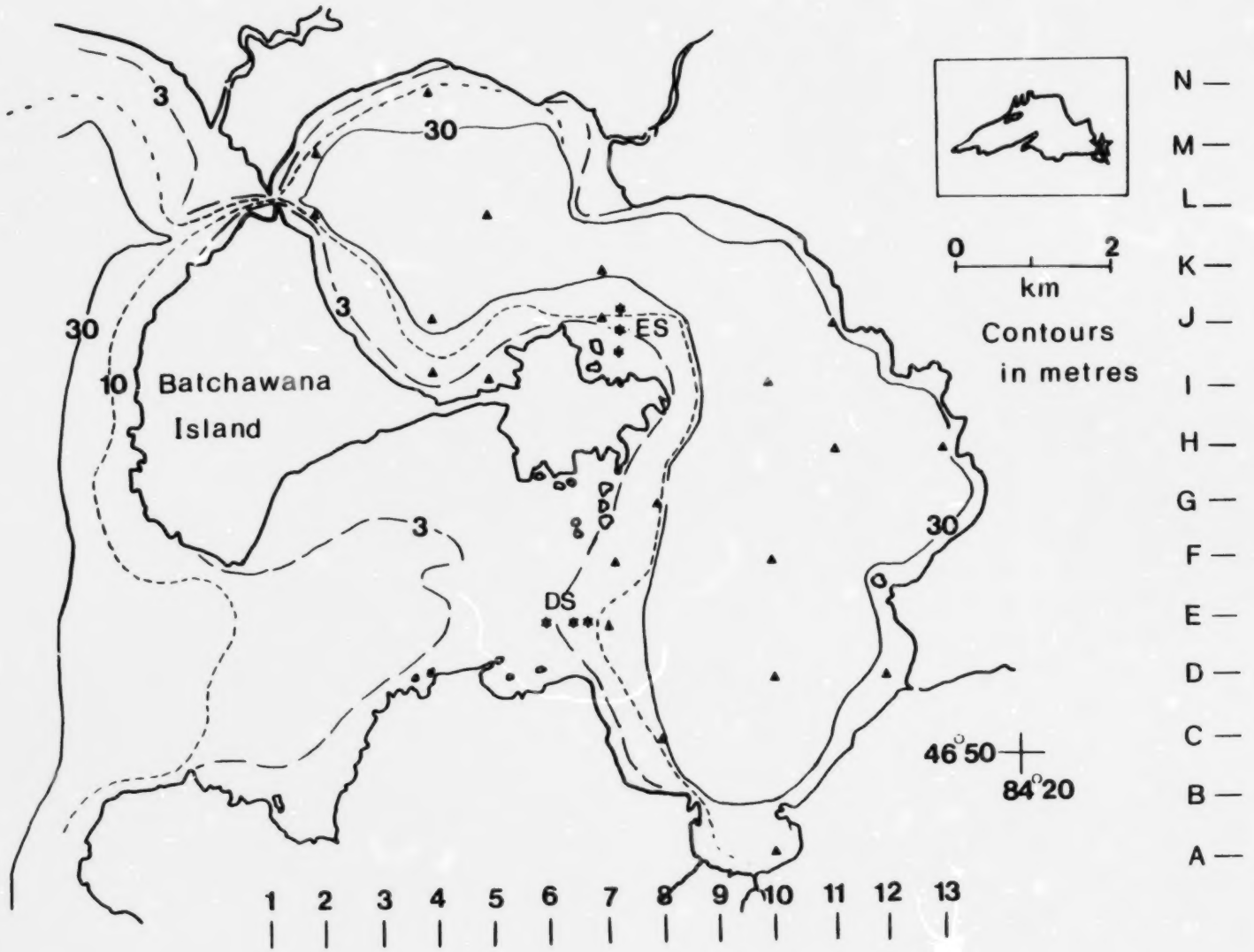
List of Figures

Figure 1. Site locations of the benthic sampling in Batchawana Bay.

Figure 2. Average benthic biomass as $g \cdot m^{-2}$ (shell-free dry weight) in Batchawana Bay during 1977.

Figure 3. Hierarchial clustering of the benthic fauna, May 1977, by Ward's minimum variance of the percent similarity of community.

Figure 4. Abundance of Pontoporeia and Chironomus at 30 m, 1976 - 1978; Chironomus not enumerated in 1978.



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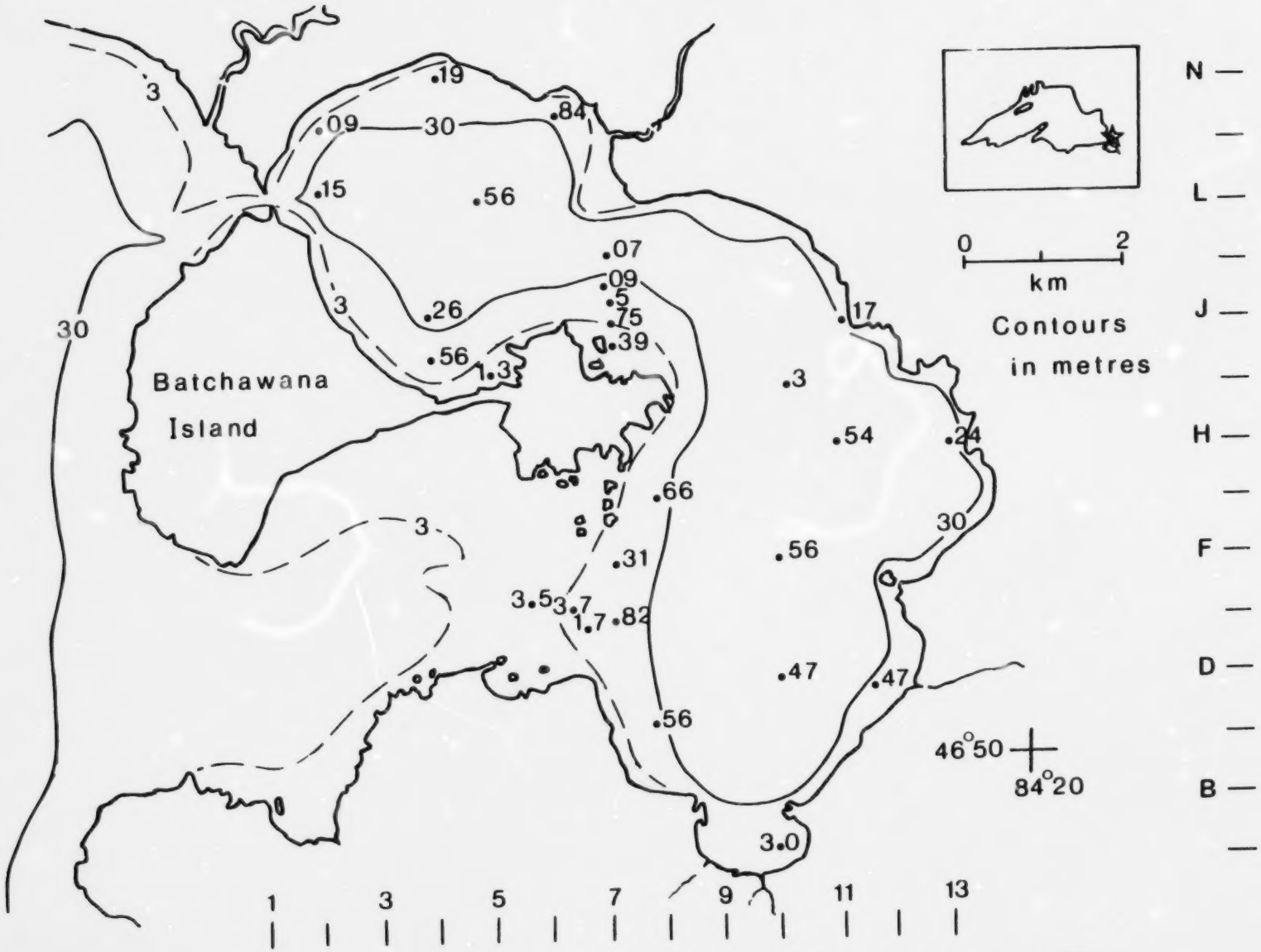
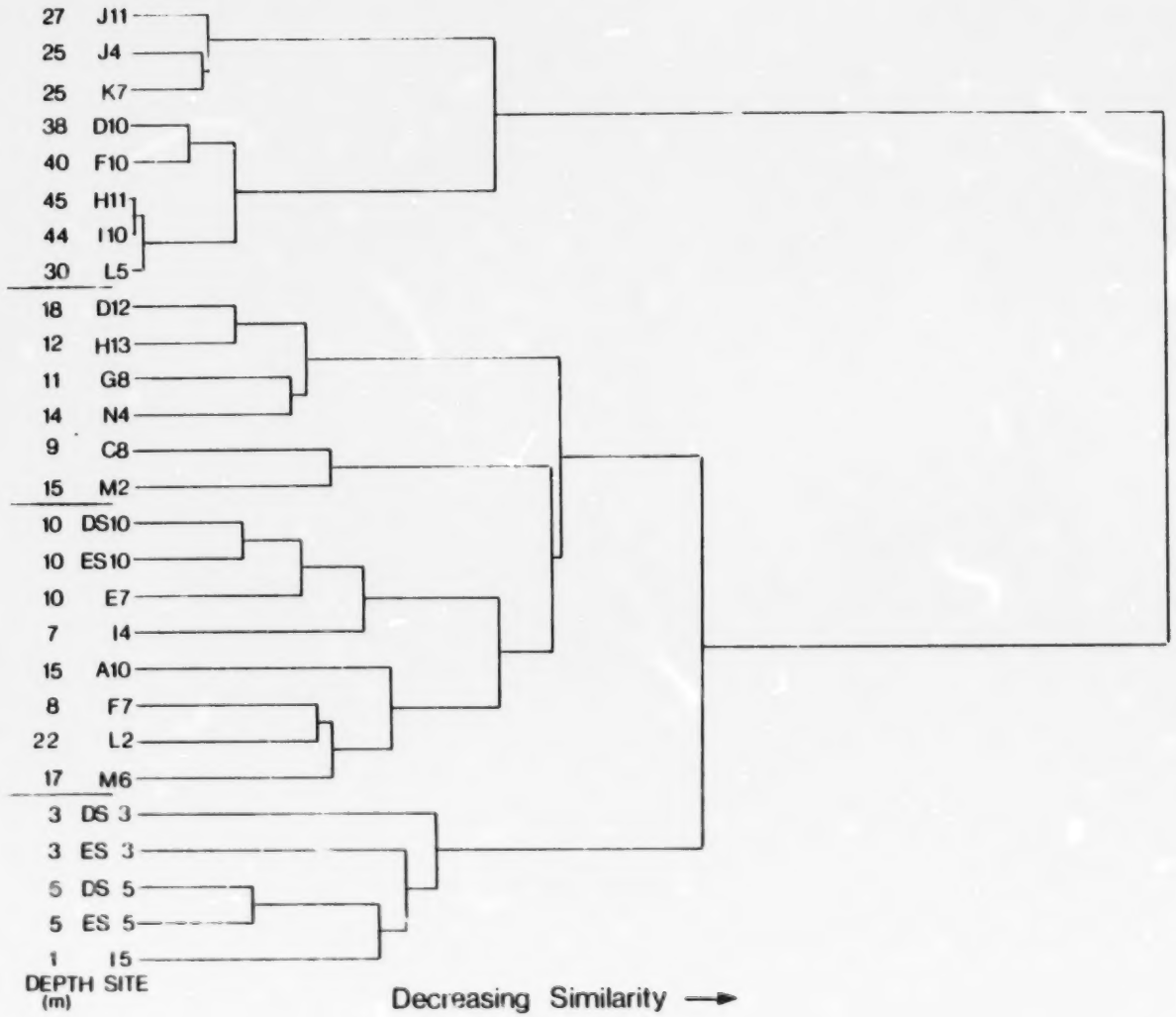


Fig.2. Average benthic biomass as g m^{-2} (shell-free dry weight) in Batchawana Bay during 1977.



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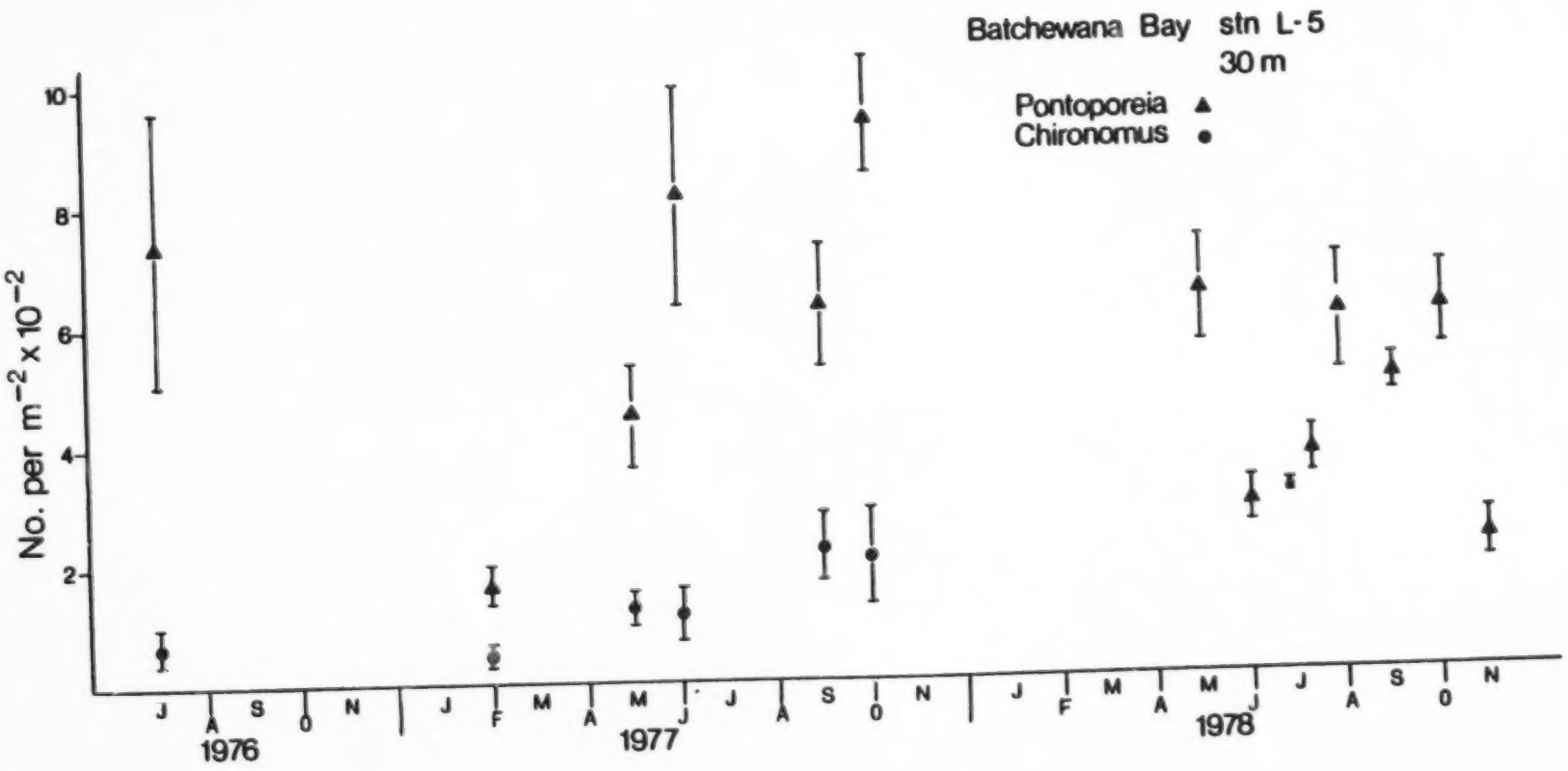

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